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Long Baseline Searches for Neutrino Oscillations

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Abstract

The results of a systematic study of potential long-baseline neutrino oscillation experiments performed with ν_μ beams from the new Fermilab Main Injector are presented.

1 Results

In this note I present the results of a systematic study[1] of long baseline neutrino oscillations using the new Fermilab Main Injector[2] as the source of protons for a new neutrino beamline to perform a short baseline neutrino oscillation experiment[3]. The experiments IMB, SOUDAN II and DUMAND have submitted proposals to be the long baseline detector[4].

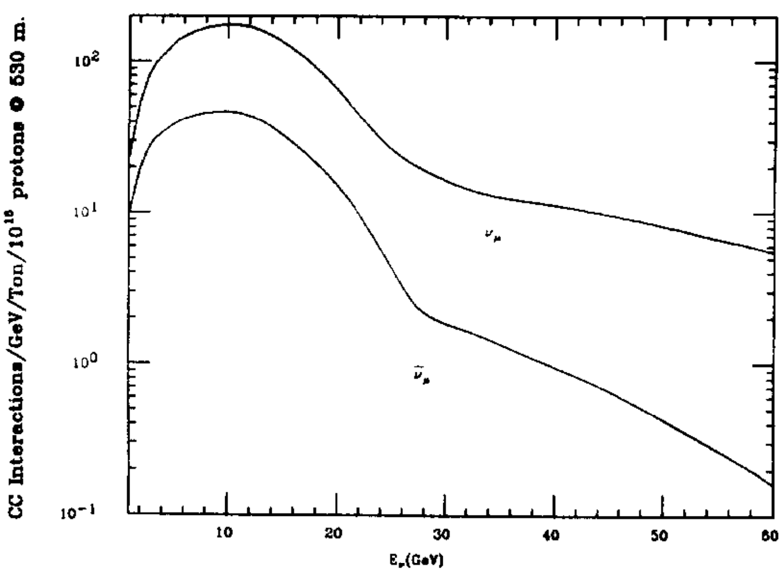

Figure 1: The ν_μ and $\bar{\nu}_\mu$ spectra weighted for the linearly rising neutrino and anti-neutrino cross-sections. The incident proton energy of the new Fermilab Main Injector is taken to be 120 GeV.

[1]Invited talk at the "Joint International Lepton-Photon Symposium and Europhysics Conference on High Energy Physics", July 25 - August 1, 1991 in Geneva, Switzerland.

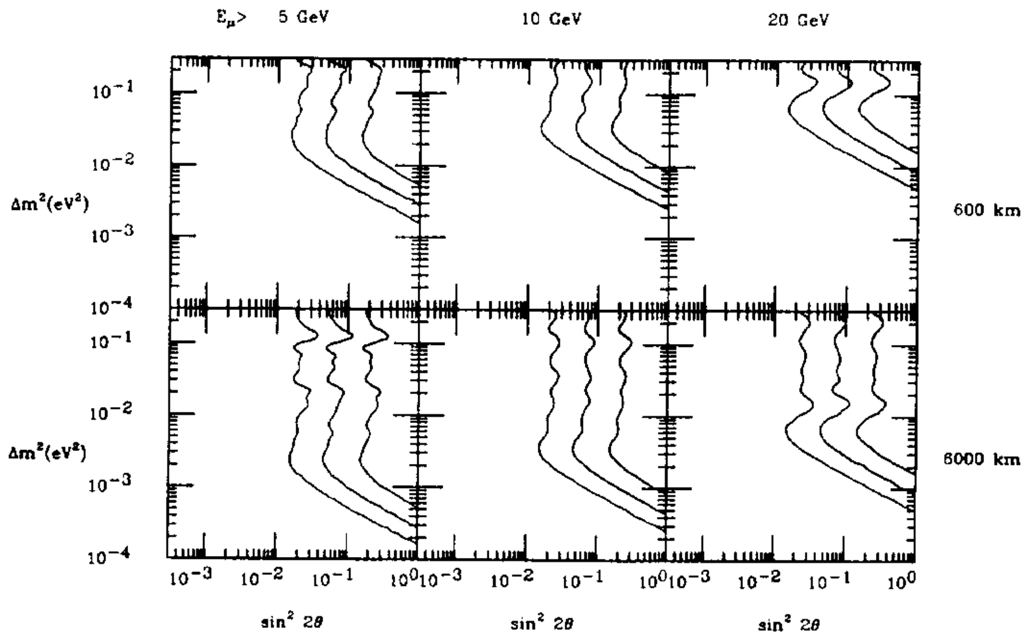

Figure 2: The excluded region in the $(\sin^2 2\theta_0,\ \Delta m_0^2)$ plane for $\nu_\mu \leftrightarrow \nu_\tau$ for $L = 600$ and 6000 km with $P_{min} = 1, 3$ and 10% and muon-detection thresholds as shown.

The spectrum of this new neutrino beam at Fermilab is given in Fig. 1. We have assumed that the long baseline detector will detect charge leptons from a neutrino charged current interaction in the detector and that the efficiency of detecting the charge lepton is zero below and unity above an *energy threshold*; 5, 10 and 20 GeV were used. The energy of this charged lepton was obtained using the appropriate structure functions for neutrinos. To model the sensitive of the experiment, whether it is an appearance or disappearance experiment, we have assumed a *mimimum measurable oscillation probability*, P_{min}, for each experiment. The value of P_{min} for a given experiment depends on many factors; mode of analysis, statisical and systematic uncertainities etc. Our ignorance of all of these factors is summarized in this P_{min}. We have used typical values for P_{min} of 1%, 3% and 10%. The results assuming $\nu_\mu \leftrightarrow \nu_\tau$ oscillations are given in Fig. 2 and for $\nu_\mu \leftrightarrow \nu_e$ oscillations including the effects of matter enhancement are given in Fig. 3 for *source-detector distances* of 600 km and 6000 km.

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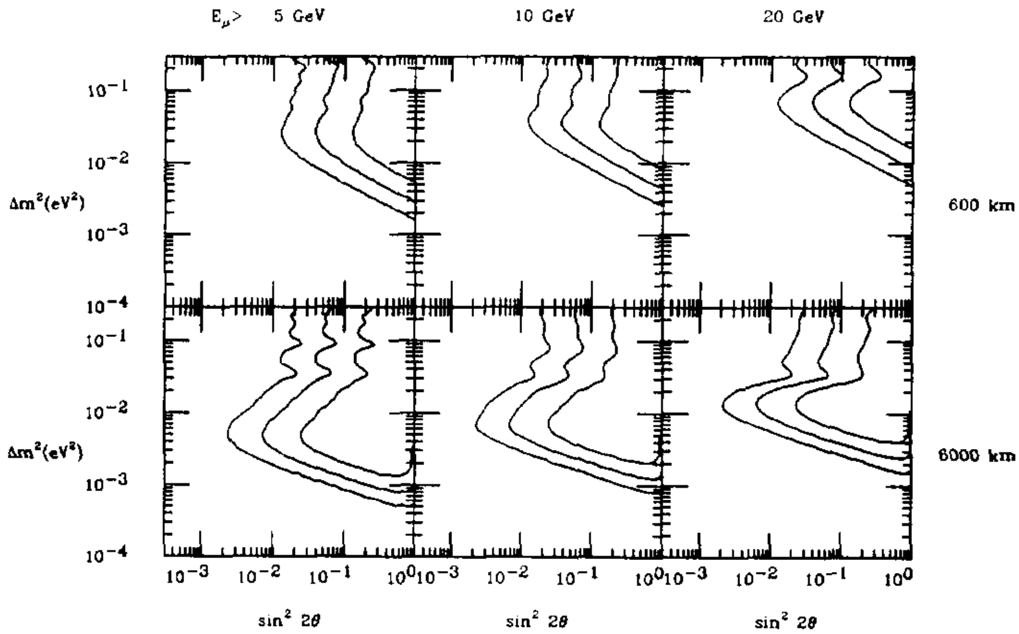

Figure 3: The exclusion region in the $(\sin^2 2\theta_0,\ \Delta m_0^2)$ plane for $\nu_\mu \leftrightarrow \nu_e$ oscillations in the Earth for $L = 600$ and 6000 km with $P_{min} = 1, 3$, and 10% and muon-detection thresholds as shown.

References

[1] R. H. Bernstein and S. J. Parke, Fermilab-Pub-91/59-T, March 1991. To be published in Phys. Rev. **D** , ().

[2] Conceptual Design Report: The Fermilab Main Injector, Rev. 2.3, FNAL, April, 1990 (unpublished); R. Bernstein *et al.*, Conceptual Design Report: Neutrino Physics after the Main Injector Upgrade, FNAL, 1991 (unpublished).

[3] K. Kodama *et al.*, Muon Neutrino to Tau Neutrino Oscillations, FNAL Proposal P–803.

[4] W. Gajewski *et al.*, A Proposal for a Long Baseline Oscillation Experiment Using a High Intensity Neutrino Beam from the Fermilab Main Injector to the IMB Water Cerenkov Detector, FNAL Proposal P–805; W. Allison *et al.*, A Long Baseline Neutrino Oscillation Experiment Using Soudan 2, FNAL Proposal P–822; DUMAND–II Collaboration, A Terrestrial Long-Baseline Neutrino Oscillation Experiment using the Proposed Fermilab Main Injector and the DUMAND Detector, FNAL Proposal P–824.